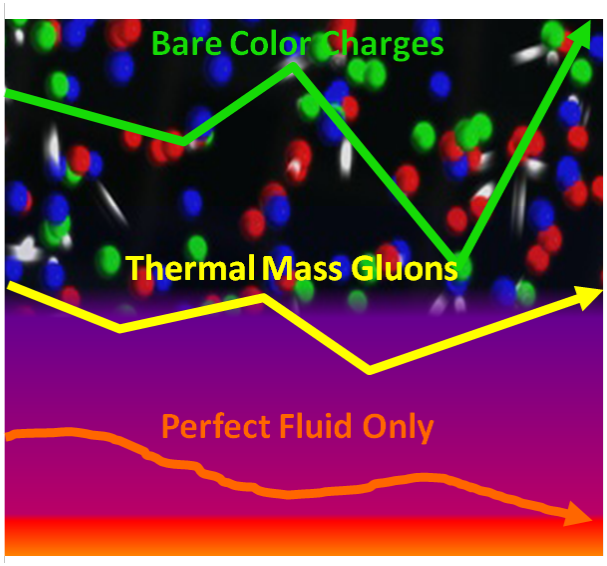
Discussion of Physics Goals

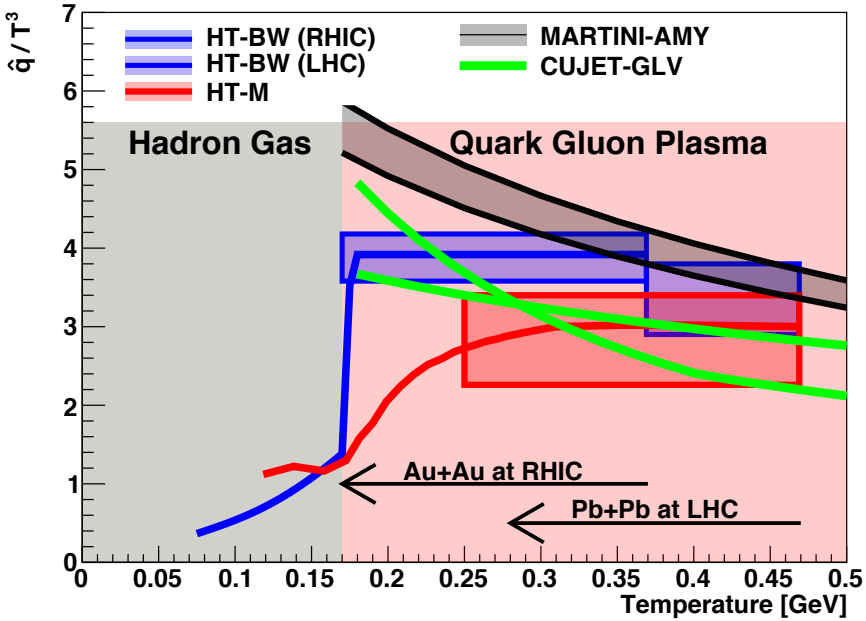
Megan Connors
GSU/RBRC

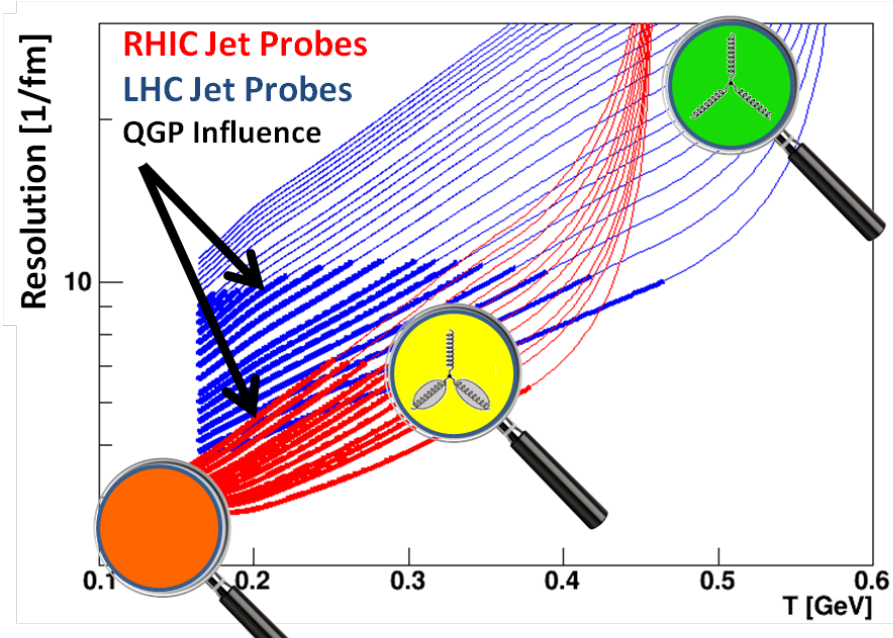
The Physics

Properties of the QGP

- Coupling Strength
- Temperature dependence
- Different length scales
- Evolution of parton virtuality

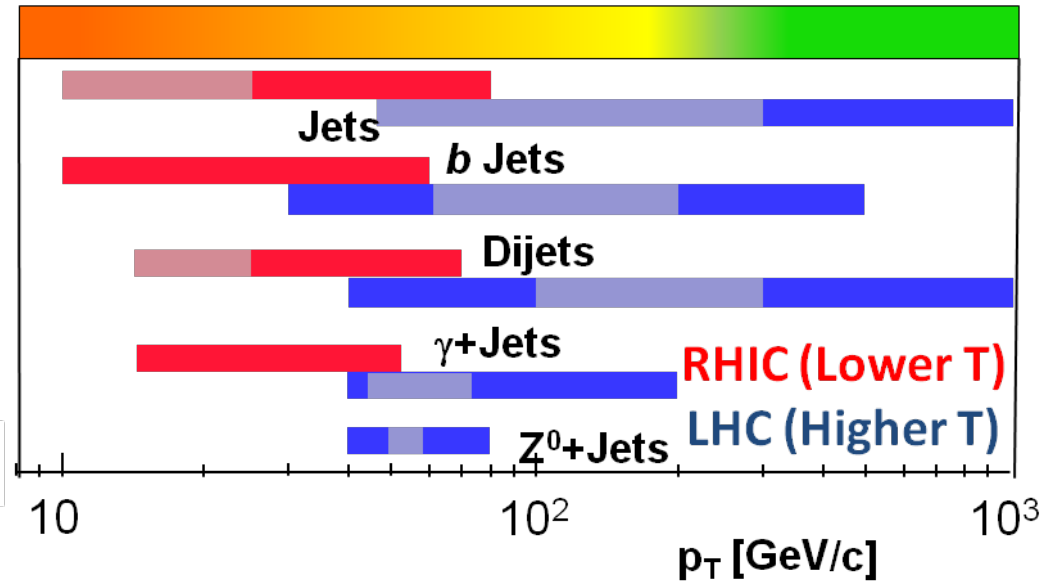


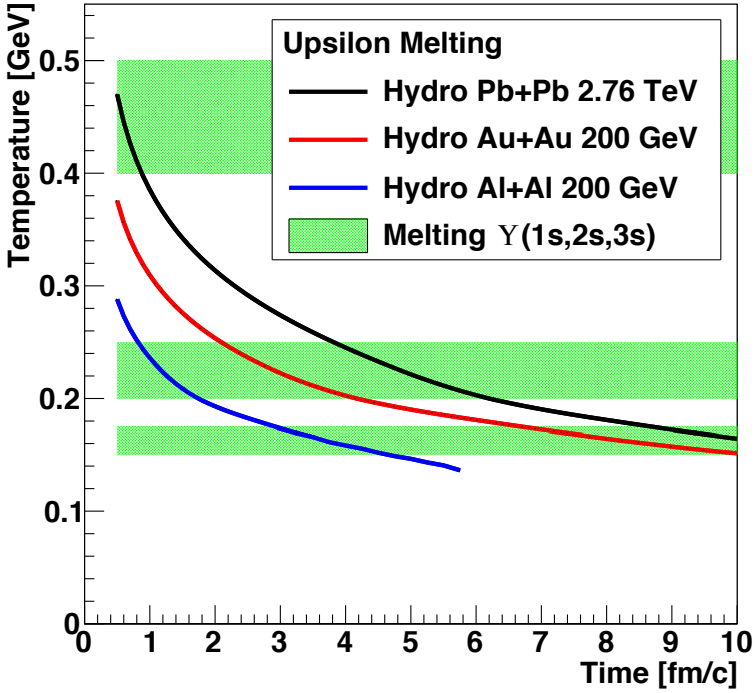




The Probes

- Jets and Upsilons





The Measurements

- Upsilon states
- Quarkonia
- Heavy flavor jets
- A_j
- Jet shapes
- Fragmentation functions
- Direct photons
- Constraining theory
- p-A

Discussion of the Morning Talks

Morning Session 3

Convener: Julia Velkovska

09:00 **Introduction to Day 2** *10'*
Speakers: Dr. Rosi Reed (Wayne State University), Sevil Salur (Rutgers University)

09:10 **Summary of IB Meeting** *25'*
Speaker: Prof. John Harris (Yale University)
Material: **Slides**

09:35 **Future of RHIC** *35'*
Speaker: Berndt Mueller (Duke University)
Material: **Slides**

10:10 **What does the theory community want to see with sPHENIX?** *35'*
Speaker: Prof. Abhijit Majumder
Material: **Slides**

Coffee Break

Morning Session 4

Convener: Sarah Campbell

11:15 **Cold QCD with Hadron Colliders** *30'*
Speaker: Prof. Christine Aidala

11:45 **EIC physics and ePHENIX** *30'*
Speaker: Dr. Alexander Bazilevsky (BNL)
Material: **Slides**

Future of RHIC

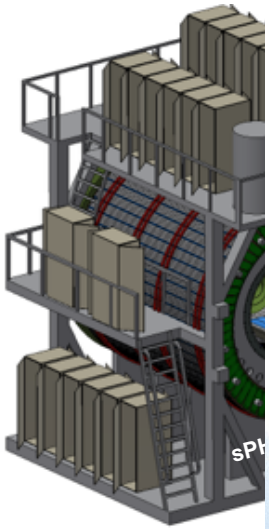
Completing the RHIC science mission

Status: RHIC-II configuration is complete

- Vertex detectors in STAR (HFT) and PHENIX
- Luminosity reaches 25x design luminosity

Plan: **Complete the RHIC mission** in 3 campaigns:

- **2014–17: Heavy flavor probes of the QGP using the micro-vertex detectors; Transverse spin physics**
- *2018: Install low energy e-cooling* (LEReC)
- **2019/20: High precision scan of the QCD phase diagram & search for critical point**
- *2021: Install sPHENIX*
- **2022–23: Probe QGP with precision measurements of jet quenching and Upsilon suppression**
- *Transition to eRHIC ?*



Challenges for sPHENIX

- Keep maturing the science case
  - JET Collaboration is over
  - There is no Quarkonium Collaboration
  - Keep the theorists engaged and preparing for the data
- Optimizing the detector design
  - Tracking
  - Calorimetry
  - Magnet flux return
  - Requires many simulations and openness to alternatives
- Broadening the community
  - Reach out to the STAR community
  - Keep developing the case for cold QCD measurements
  - Establish liaison to EIC community
- Perseverance
  - Tough choices and hard times are just around the corner!

- Making the physics case for extended running
- Compelling physics for fsPHENIX
  - Spin physics at mid-rapidity?
- Upgrade capabilities for ePHENIX

PHENIX

What a theorist wants to see with sPHENIX

Abhijit Majumder

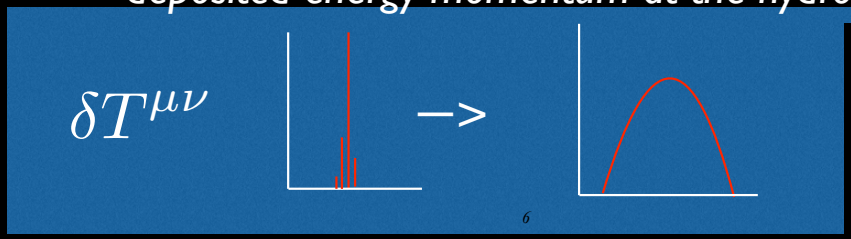
In general, 2 kinds of transport coefficients

Type 1: which quantify how the medium changes the jet

$$\hat{q}(E,Q^2) \qquad \hat{q}_4(E,Q^2) = \frac{\langle p_T^4 \rangle - \langle p_T^2 \rangle^2}{L} \ldots$$

$$\hat{e}(E,Q^2) \qquad \hat{e}_2(E,Q^2) = \frac{\langle \delta E^2 \rangle}{L} \qquad \hat{e}_4(E,Q^2) = \frac{\langle \delta E^4 \rangle - \langle \delta E^2 \rangle^2}{L} \ldots$$

Type 2: which quantify the space-time structure of the deposited energy momentum at the hydro scale



What should we measure?

- Leading hadrons
- Reconstructed jets
- Near and away-side
- Jet shapes

Higher Order Coefficients?

Summary

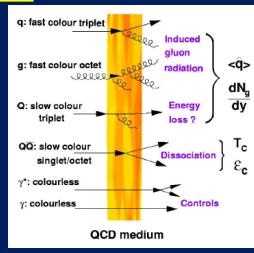
- Jets are a window to both static and dynamic properties of the QGP
- These are revealed through type 1 and type 2 transport coefficients
- The effect of Type 2 depends on the magnitude of type 1
- Hadronization in the presence of a medium complicates all phenomena
- S-PHENIX will allow for wide range of kinematics at lower temperatures close to the phase transition
- In order to extract the maximal amount of information from S-PHENIX and LHC program, next gen. MCs need to be in place.

Generic detector requirements

- Coverage approximately $1<\eta<4$
- Calorimetry (EM and HCal)
- Tracking
- Roman pots
- Hadron PID for hadronization measurements

QCD interactions

- QCD interactions themselves increasingly an explicit focus, e.g.
  - Parton energy loss traversing cold or hot QCD matter
  - Hadronization, in various environments
  - Quantum phase interference and phase shifts
  - Predicted color entanglement of partons *across* colliding protons
  - For hadronic final states sensitive to nonperturbative [illegible]erse momentum



"Cold" QCD physics areas of focus (Many are linked to one another!)

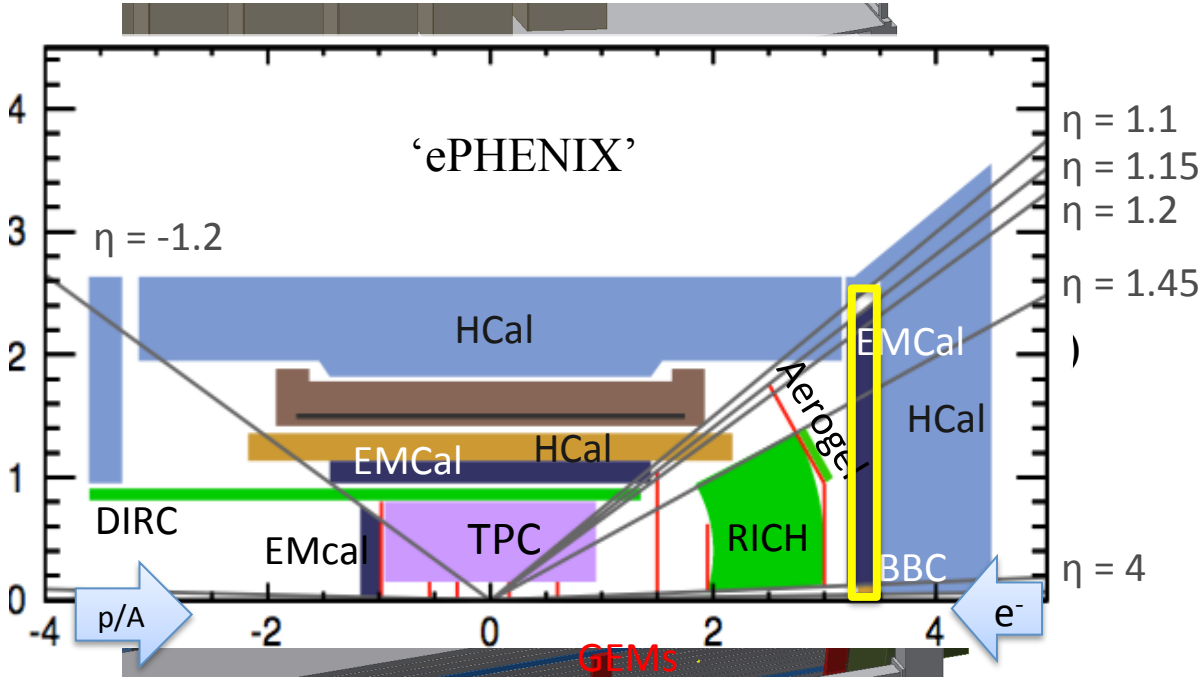
- Diffraction
- Partonic structure of nuclei/nuclear pdfs
- Low-x/Saturation
- Spin-momentum correlations, interference effects and their process dependence
- Hadronization in different environments

- At RHIC: focus on measurements in support of or complementary to future EIC physics program
  - Unique color interactions
  - Early measurements to gauge scale of effects/observables to be studied in depth at EIC
  - Draw larger community into physics and observables of EIC

Studying Cold QCD with Hadron Colliders

sPHENIX + fsPHENIX –> ePHENIX

- Make sure s(f)PHENIX concept is consistent with ePHENIX plans
- fsPHENIX = sPHENIX +
  - PHENIX reconfigured: forward Si tracker, Muon ID (and EMCal?)
  - EIC Detector forward systems: GEMs and HCal
  - 90% of the cost common with EIC detector



In current sPHENIX design:

Plug door (flux return) at 3.3m

Could we move EMCal towards IR?

Will 20-30cm of iron deteriorate HCal measurements?

Don't see principle limitations, but need simultion


Extra Cheese
Sausage
Meat Ball
Mushroom
Pepperoni
Pepper
CUSTOMER
Onions
Anchovies
Special